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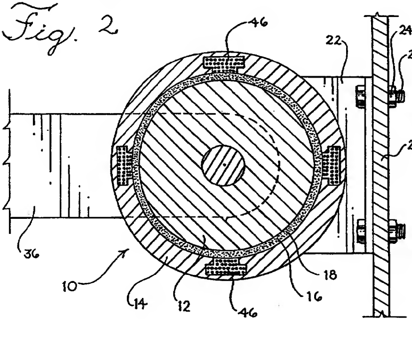
(54) Abstract Title

A magneto-rheological fluid-controlled vehicle suspension damper

(57) A magneto-rheological fluid actuated damper 10 has at least a first cylinder 12 and a second cylinder 14 with the first cylinder 12 positioned axially within the second cylinder 14, a gap 16 being formed between the cylinders 12, 14. The second cylinder 14 is mounted via a bracket 22 to a stationary mount of the vehicle chassis 20 and a suspension control arm 36 is mounted at an end of the first cylinder 12. The first cylinder 12 is mounted on bearings to allow it to rotate relative to the chassis 20. The gap 16 between the cylinders contains a magneto-rheological fluid 18 having an adjustable viscosity in reaction to the application of a magnetic field which is generated over the fluid 18 in the gap 16 by, for example, an electro-magnetic coil 46. The magnetic field being varied in response to measured parameters, e.g. wheel velocity, wheel displacement and chassis acceleration, via a controller (53 in Fig.12).

Fig. 2



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

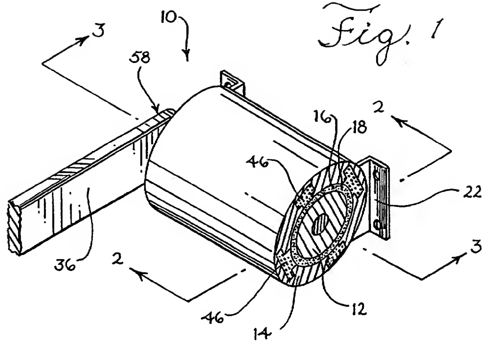


Fig. 1

Fig. 2

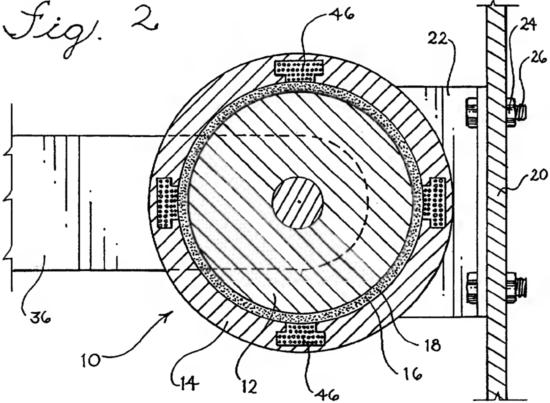


Fig. 3

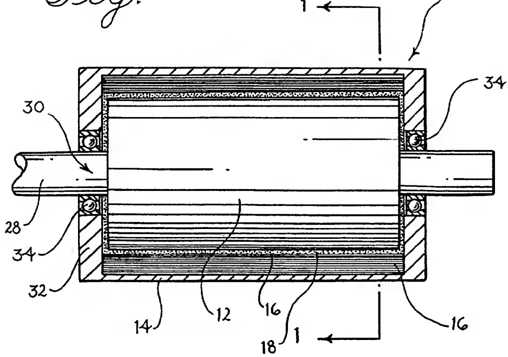


Fig. 4

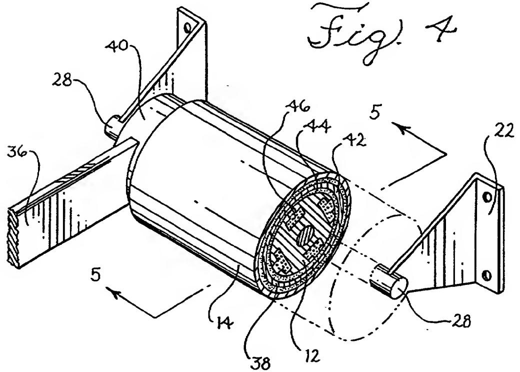
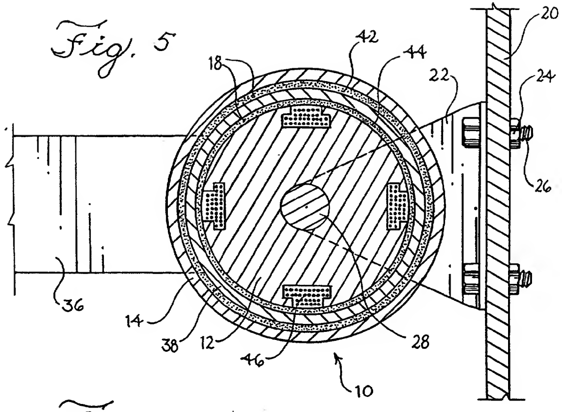


Fig. 5


20
42
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18
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26
36
14
38
12
46
28
10

Fig. 6

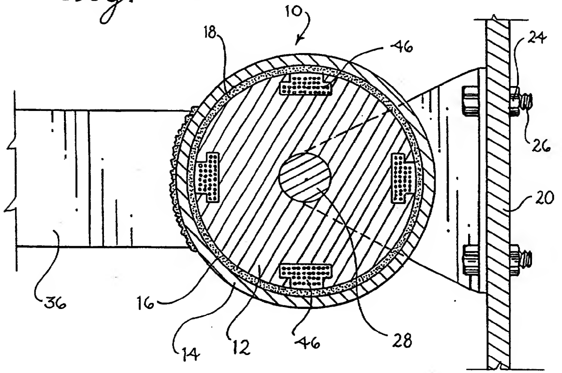

10
18
46
24
26
20
36
16
14
12
46
28

Fig. 7

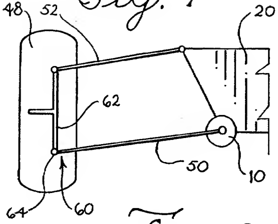


Fig. 8

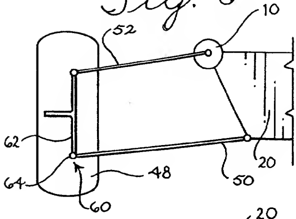
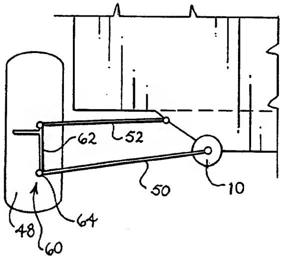


Fig. 9



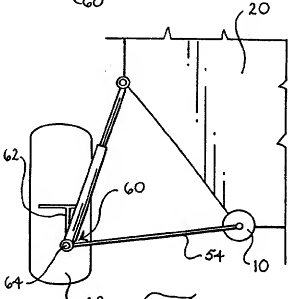


Fig. 10

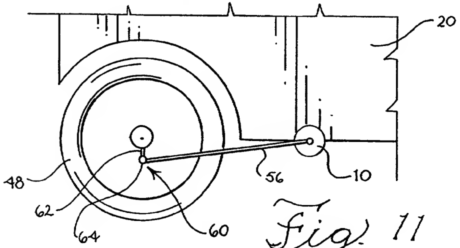


Fig. 11

Fig. 12

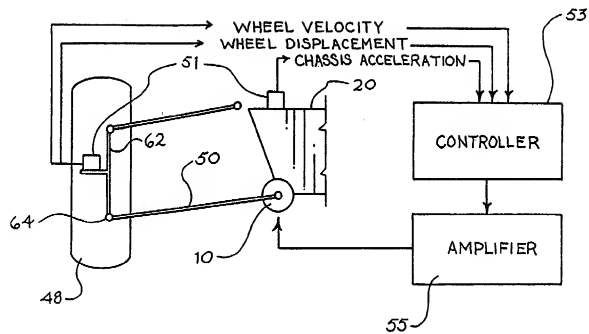
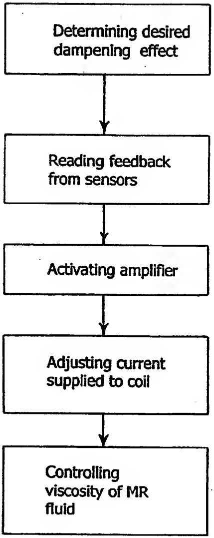

WHEEL VELOCITY
WHEEL DISPLACEMENT
CHASSIS ACCELERATION
53
51
20
62
50
CONTROLLER
64
10
AMPLIFIER
48
55

Fig. 13


Determining desired dampening effect
Reading feedback from sensors
Activating amplifier
Adjusting current supplied to coil
Controlling viscosity of MR fluid

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Magnetorheological Fluid-controlled Vehicle Suspension Damper

Field of the invention

The invention relates generally to the field of suspension systems for vehicles. In particular, the invention relates to a magnetorheological fluid actuated damper for use in vehicular suspension systems.

Description of the related art

Suspension systems are used in modern vehicles to tune the characteristics of the ride and handling of the vehicle. The suspension system in each type of vehicle is matched to the type of ride that the operator of that vehicle would prefer. Some vehicles have suspension systems that provide a smoother ride than others and some vehicles have tighter, more precise handling characteristics. More modern suspension systems often allow an operator to choose the type of ride for the vehicle. For example, an operator might desire a "softer" ride when driving over rougher terrain and a "harder" ride with more precise handling when driving on smooth terrain.

A magnetorheological ("MR") fluid is a substance that relies on a magnetically capable media compounded in a way that allows the substance to change form from a liquid state to a more viscous state. In one form, an MR fluid has a viscosity and consistency much like common motor oil. When a magnetic field is applied, however, the fluid changes form, becoming more resistant to shear force. This increase in viscosity results from a dipole moment introduced into magnetic particles suspended in the fluid from the magnetic field. The

particles form chains, aligning in parallel to the magnetic field. The increase in viscosity depends on the strength of the field applied to the fluid and the size and quantity of the particles. This change in viscosity of the fluid takes place within milliseconds.

Because of the capability to change viscosity quickly and easily, MR fluids have been used to provide adjustable resistance in many types of systems. For example, US Patent 5,816,372 discloses a system for use in an exercise machine to control the resistance in exercise equipment. The system includes a spinning rotor within a housing and an MR fluid in place between the rotor and the housing. In order to increase the resistance a user feels while exercising, a magnetic field is applied to the MR fluid and the increased viscosity of the MR fluid makes it more difficult to rotate the rotor. A similar system is disclosed in US Patent 6,186,290 for use as a braking system.

MR fluids have also been used in telescopic dampers in vehicles. A telescopic damper can be filled with MR fluid to provide adjustable resistance to the vertical movement of the wheel of a vehicle. A telescopic damper utilizing MR fluid requires a substantial amount of MR fluid to be viable and a large magnetic field to operate. Another type of damper utilizing MR fluid is a rotary shock absorber of the type disclosed in US Patents 4,942,947 and 5,257,681. This type of shock absorber allows the dampening of relative movement between a blade attached to a shaft in connection with a wheel of a vehicle, and the housing around the blade. The system provides a means to apply an adjustable magnetic field to an MR fluid in the housing to control the movement of the blade in relation to the housing. It is desirable to further

increase the adjustability of this type of vehicular dampening system while minimizing the cost of the system.

Brief summary of the invention

According to one embodiment of the invention, there is provided a magnetorheological fluid actuated damper for use in vehicular suspension systems, said damper comprising:

at least a first and a second concentric cylinder, said first cylinder being positioned axially within said second cylinder, so as to form a gap between said pair of cylinders;

one of said pair of cylinders being mountable to a stationary mount of a vehicle chassis;

the other of said pair of cylinders having a control arm mounted at an end of said cylinder, and being mounted on bearings to allow rotation of said first cylinder relative to said chassis;

said gap between said pair of cylinders containing a magnetorheological fluid having adjustable viscosity in reaction to the application of a magnetic field; and

a means for generating a magnetic field over said fluid in said gap.

According to another embodiment of the invention, there is provided a magnetorheological fluid actuated damper for use in vehicular suspension systems, said damper comprising:

at least three concentric cylinders defining gaps therebetween;

a first gap defined between a first and a third cylinder;

a second gap defined between a second cylinder and said third cylinder;

said first cylinder and/or said second cylinder being mountable to a stationary mount of a vehicle chassis;

said third cylinder being attached to a first end of a control arm at an end of said third cylinder;

said third cylinder being mounted on bearings to allow rotation of said third cylinder relative to said first and said second cylinders;

said first and said second gaps between said cylinders containing a magnetorheological fluid; and

a means for generating a magnetic field over said fluid in said gap.

The invention also provides a method for adjustably dampening the suspension system of a vehicle through the use of a magnetorheological fluid actuated damper, said damper being according to the invention, the method comprising the steps of:

determining a desired level of dampening;

reading feedback from sensors on the vehicle; and

controlling the viscosity of said magnetorheological fluid through the application of a magnetic field on said magnetorheological fluid such that the resistance to rotation of said relatively rotatable cylinders changes in response to the change in viscosity of said magnetorheological fluid.

Brief description of the drawings

The invention will now be further described, by way of example only and with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of an embodiment of the present invention;

Figure 2 is a cross-sectional view along line 2-2 in Figure 1;

Figure 3 is a cross-sectional view along line 3-3 in Figure 1;

Figure 4 is a perspective view of an alternative embodiment of the present invention;

Figure 5 is a cross-sectional view along line 5-5 in Figure 4;

Figure 6 is a cross-sectional view of another alternative embodiment of the present invention;

Figure 7 is a schematic view of the positioning of the present invention on the lower control arm of a double-wishbone suspension system;

Figure 8 is a schematic view of the positioning of the present invention on the upper control arm of a double-wishbone suspension system;

Figure 9 is a schematic view of the positioning of the present invention on the lower control arm of a double wishbone suspension system in a low floor installation;

Figure 10 is a schematic view of the positioning of the present invention on the upper control arm of a strut suspension system;

Figure 11 is a schematic view of the positioning of the present invention on the trailing arm of a solid axle suspension system;

Figure 12 is a schematic view of an example of a control system for use with the present invention; and

Figure 13 is a flow chart showing the steps of the method of the present invention.

Detailed description of the preferred embodiments of the invention

Referring in combination to Figures 1-3, a preferred embodiment of the MR-actuated damper 10 of the present invention is shown. First 12 and second 14 cylinders are provided. The second cylinder 14 preferably has a hollow interior that is shaped and sized to be slightly larger than the outer diameter of the first cylinder 12. The first cylinder 12 is positioned inside the hollow interior of the second cylinder 14 such that the first cylinder 12 and the second cylinder 14 are not in contact with each other.

The positioning of the first cylinder 12 inside the second cylinder 14 forms a gap 16 between the first 12 and second cylinders 14. This gap 16 is preferably filled with an MR fluid 18. The damper 10 is preferably sealed at a side wall 32 of the second cylinder 14 so that the MR fluid 18 does not leak out of the damper 10. Since the gap 16 is preferably substantially thin, only a small volume of MR fluid 18 is required to fill the entire gap 16. The small MR fluid 18 requirement of the present invention reduces the cost of the

damper 10 and also reduces the necessary strength of the seal in the damper 10.

In the embodiment of the present invention shown in Figures 1-3, the second cylinder 14 is preferably attached to the chassis 20 of the vehicle. The preferred mounting method shown in the Figures includes a standard bracket 22 welded to the second cylinder 14 and attached to the chassis 20 by nuts 24 and bolts 26. Other attachment methods are possible. For example, the second cylinder 14 could be attached to the chassis utilizing any method known in the art. The attachment method should prevent any movement or rotation of the second cylinder 14 such that the second cylinder 14 acts as a stator.

In the embodiment of the present invention shown in Figures 1-3, the first cylinder 12 includes a shaft 28 extending from the interior of the cylinder 12. The shaft 28 preferably extends through a hole 30 in the side wall 32 of the second cylinder 14. Bearings 34 are preferably provided in contact with the shaft 28 of the first cylinder 12 to allow the first cylinder 12 to rotate relative to the second cylinder 14 while holding the first cylinder 12 in place within the second cylinder 14. The first cylinder 12 preferably does not contact the second cylinder 14.

The shaft 28 preferably attaches to a control arm 36 of the suspension system. The movement of the control arm 36 rotates the first cylinder 12 relative to the second cylinder 14. The movement of the control arm 36 will be further explained in reference to Figures 7-11, which show the damper 10 mounted in various locations in the suspension system of a vehicle.

It is also possible to reverse the mounting arrangement of the first 12 and the second 14 cylinders. Figure 6 shows an alternate embodiment of the present invention wherein the first cylinder 12 is mounted to a bracket 22 attached to the chassis 20 of the vehicle. As noted previously, the method of attachment shown is exemplary. The second cylinder 14 is attached to a control arm 36 of the suspension system. The gap 16 between the first 12 and second cylinders 14 is filled with MR fluid 18. In this embodiment, the second cylinder 14 rotates relative to the first cylinder 12, which acts as the stator. The rotation of the second cylinder 14 is created through the movement of the control arm 36.

It is also possible to create a stacked arrangement utilizing the present invention. In Figures 4 and 5, a stacked arrangement of the present invention is shown. In a stacked arrangement, three concentric cylinders 12, 14, 38 are provided. The second cylinder 14 preferably has the largest diameter and is mounted to the chassis 20 such that it cannot rotate and acts as a stator. The second cylinder 14 has a hollow interior. The third cylinder 38 also has a hollow interior and is positioned axially within the second cylinder 14 such that the third 38 and second 14 cylinders are not in contact with each other. The third cylinder 38 is preferably longer than the first 12 and the second 14 cylinders and has a section 40 that extends past the side walls 32 of the second cylinder 14. The third cylinder 38 is mounted on bearings (not shown) located in the side of the second cylinder 14 in a similar manner as in the embodiment of the present invention shown in Figure 3. This configuration allows the third cylinder 38 to rotate in reaction to the movement of the control arm 36. The first cylinder 12 has a smaller diameter than the third cylinder 38 and has a shaft

28 extending from it. The shaft 28 attaches the first cylinder 12 to the chassis 20 such that the first cylinder 12 cannot rotate. In this embodiment, the third cylinder 38 rotates relative to the first 12 and second 14 cylinders.

The positioning of the third cylinder 38 between the first 12 and the second cylinders 14 creates a first gap 42 and a second gap 44. Both the gaps 42, 44 are filled with an MR fluid 18. The stacked arrangement of this damper 10 allows for an even greater amount of dampening control while still utilizing a small volume of MR fluid 18 due to the greater surface area of the first 12 and second 14 cylinders in contact with the MR fluid 18.

The adjustable resistance of the damper 10 of the present invention will now be described with reference to the embodiment shown in Figures 1-3. It is important to recognize that the invention operates in the same manner regardless of which cylinder acts as the stator and which is rotatable. The damper's 10 method of operation is not necessarily dependent on the number of cylinders in the embodiment.

The viscosity of the MR fluid 18 between the cylinders 12, 14 of the damper 10 can be easily adjusted. In its resting form, the MR fluid 18 has a consistency similar to motor oil and allows the first cylinder 12 to rotate relative to the second cylinder 14 with relatively small resistance. This allows the control arm 36 to move freely, with minimal resistance from the damper 10. The viscosity of the MR fluid 18 is adjusted by the application of a magnetic field to the MR fluid 18. When a magnetic field is applied to the MR fluid 18, the viscosity of the MR fluid 18 increases and the MR fluid 18 becomes thicker, taking on a consistency similar to a paste.

This thicker consistency creates more resistance on the first cylinder 12 and makes it necessary to apply more force to the control arm 36 in order to rotate the first cylinder 12. This increased resistance to rotation results in a higher dampening level and less "give" for the control arm 36. Typically, higher performance vehicles use higher dampening levels to achieve improved handling and precision.

In order to change the viscosity of the MR fluid 18, a means for supplying a magnetic field must be provided. Preferably, a magnetic coil comprised of solenoid windings 46 is in place within one of the cylinders 12, 14, 38. Figures 1 and 2 show an embodiment of the present invention with solenoid windings 46 in place in the interior of the second cylinder 14. It is also possible to place the solenoid windings 46 around the outer diameter of the second cylinder 14. Figures 4-6 show embodiments of the present invention with the solenoid windings 46 in place in the interior of the first cylinder 12. It is also possible to position the solenoid windings in the interior of the third cylinder 38. Regardless of the placement of the solenoid windings 46, the windings 46 are preferably attached to an electronic circuit (not shown). The circuit allows a variable current to be supplied to the solenoid windings 46, which in turn allows the creation of variable magnetic fields. The strength of the magnetic field affects the viscosity of the MR fluid 18. The stronger the magnetic field, the higher the viscosity of the MR fluid 18. At higher viscosities, more force must be applied to the control arm 36 to rotate the rotatable cylinder.

Referring to Figure 12, a schematic depiction of a simple control system is shown. The circuit is preferably connected to a controller 53 in the vehicle that controls an amplifier

55 capable of varying the current in response to the relative motion between the wheel 48 of the vehicle and the chassis 20 in real time. Sensors 51 are utilized to measure the wheel 48 velocity, wheel 48 displacement and chassis 20 velocity. These measurements are communicated to the controller 53. The sensors 51 provide feedback to the controller 53 that in turn activates an amplifier 55 to adjust the current supplied to the solenoid windings 46 to adjust the damping force of the damper 10. As these forces change, the controller 53 measures the velocity and displacement of the wheel 48 and the acceleration of the chassis 20 and the amplifier 55 continuously adjusts the magnetic field supplied by the solenoid windings 46. The adjustment of the current allows the damper 10 to control the damping force as a function of relative speed. The continuously controllable damping force supplied by the damper 10 of the present invention allows the handling and ride of the vehicle to be optimized in real time. Other computerized control and sensing systems known in the art can be added to further optimize the damping system and allow more operator control.

The damper 10 of the present invention can be mounted in the suspension system of a vehicle in any number of ways known in the art. Figures 7-11 illustrate schematic examples of preferred placements of the damper 10. The stationary cylinders may be attached to the chassis 20 in any manner known in the art. These figures are exemplary only. Figures 7-9 show the damper 10 of the present invention mounted in a short-long arm ("SLA") or double-wishbone suspension system. The damper 10 of the present invention may be installed on the long arm 50 of the SLA suspension system as shown in Figure 7 or the short arm 52, as shown in Figure 8. The damper 10 is more effective if it is positioned on the short

arm 52, but it can still operate effectively on the long arm 50. It is also possible to mount the damper 10 of the present invention in a low floor SLA installation, as shown in Figure 9. The damper 10 of the present invention may also be installed on the control arm 54 of a strut system, as shown in Figure 10. Figure 11 shows the damper 10 of the present invention installed on the trailing arm 56 of a solid axle suspension system. In any installation, the control arm is attached to the rotatable cylinder of the damper 10 at a first end 58 of the control arm. The second end 60 of the control arm is preferably attached to the knuckle 62 of the wheel 48 at a pivot point 64. The pivot point 64 is commonly a ball joint or a bushing, but may be any pivotable connection known in the art. The vertical movement of the wheel 48 causes the control arm to oscillate and to rotate the rotatable cylinder of the damper 10.

Another embodiment of the present invention, a method for adjustably dampening the suspension system of a vehicle through the use of an MR fluid actuated damper 10, is shown in Figure 13 as a flowchart. The method includes the steps of providing a damper 10 having an arrangement of concentric cylinders 12,14 as previously described. A second cylinder 14 is attached to the chassis 20 of the vehicle so that it cannot rotate and the first cylinder 12 is mounted in bearings 34 such that it can rotate relative to the second cylinder 14. The first cylinder 12 is attached to a control arm 36 of the vehicle's suspension system such that the vertical movement of the wheel 48 of the vehicle causes the control arm 36 to oscillate and rotate the first cylinder 12. An MR fluid 18 is provided in the gap 16 between the cylinders 12,14. The method includes the step of first determining the desired dampening effect. The controller 53

reads the feedback from the sensors 51 and activates the amplifier 55. The amplifier 55 adjusts the current supplied to the solenoid windings 46 which creates a magnetic field. An increase in the magnetic field causes the viscosity of the MR fluid 18 to increase such that the resistance to rotation of the first cylinder 12 changes in response to the change in viscosity. Increasing the viscosity of the MR fluid 18 increases the force necessary to rotate the first cylinder 12 and decreasing the viscosity of the MR fluid 18 decreases the force necessary to rotate the first cylinder 12.

The MR fluid actuated damper 10 of the present invention provides many advantages over traditional telescopic dampers that utilize controllable fluids. The damper 10 of the present invention allows a control system to continuously vary the damping force in real time, resulting in a smoother ride with precise handling capabilities when necessary. The present invention also allows for improved packaging space, as shown in the low floor SLA installation in Figure 9. This installation does not intrude into the cargo space of the vehicle. The installation of a traditional telescopic damper restricts the cargo space of the vehicle by requiring either the floor to be higher or the trunk width to be narrower to accommodate the telescopic damper, much like the arrangement shown in Figure 10. The damper 10 of the present invention also replaces an inboard pivot point of the suspension system with a low friction device, unlike the ball joints or bushings used in traditional pivot points 64. The friction between the parts in traditional pivot points 64 causes more wear on them and they need to be replaced more often than a damper 10 of the present invention. The damper 10 of the present invention also requires less MR fluid than telescopic dampers utilizing MR fluid. Less than half of the amount of

MR fluid is required in the damper of the present invention compared with telescopic dampers because of the increased surface area in the cylinders in contact with the MR fluid. This increased surface area also provides improved cooling characteristics over telescopic dampers. The internal MR fluid pressure in the damper 10 of the present invention is also much lower than in a telescopic damper, and this reduces sealing problems common in telescopic, fluid-controlled dampers. The frictionless aspect of the damper 10 of the present invention results in less wear on the damper 10, unlike the rod and bore wear that is common in telescopic dampers.

It should be noted that there could be a wide range of changes made to the present invention without departing from its scope. For example, the size of and thickness of the cylinders could be varied to match the specifications of the vehicle in which the damper 10 is installed. It is also possible to stack more than three cylinders together in order to increase even further the controllability of the damper 10. Other control systems could be used along with different sensing systems to control the viscosity of the MR fluid and thus the damping characteristics of the damper 10. The damper 10 of the present invention could be mounted in suspension systems other than the examples pictured and could be mounted through the use of different attachment methods known in the art. Thus, it is intended that the foregoing detailed description be regarded as illustrative rather than limiting and that it be understood that it is the following claims, including all equivalents, which are intended to define the scope of the invention.

Claims:

1. A magnetorheological fluid actuated damper for use in vehicular suspension systems, said damper comprising:

at least a first and a second concentric cylinder, said first cylinder being positioned axially within said second cylinder, so as to form a gap between said pair of cylinders;

one of said pair of cylinders being mountable to a stationary mount of a vehicle chassis;

the other of said pair of cylinders having a control arm mounted at an end of said cylinder, and being mounted on bearings to allow rotation of said first cylinder relative to said chassis;

said gap between said pair of cylinders containing a magnetorheological fluid having adjustable viscosity in reaction to the application of a magnetic field; and

a means for generating a magnetic field over said fluid in said gap.

2. A magnetorheological fluid actuated damper for use in vehicular suspension systems, said damper comprising:

at least three concentric cylinders defining gaps therebetween;

a first gap defined between a first and a third cylinder;

a second gap defined between a second cylinder and said third cylinder;

said first cylinder and/or said second cylinder being mountable to a stationary mount of a vehicle chassis;

said third cylinder being attached to a first end of a control arm at an end of said third cylinder;

said third cylinder being mounted on bearings to allow rotation of said third cylinder relative to said first and said second cylinders;

said first and said second gaps between said cylinders containing a magnetorheological fluid; and

a means for generating a magnetic field over said fluid in said gap.

3. A magnetorheological fluid actuated damper as claimed in Claim 1, wherein: the first cylinder is the cylinder that has said control arm mounted at said end of said first cylinder, and that is mounted on bearings to allow rotation of said first cylinder relative to said chassis; and the second cylinder is the cylinder that is mounted to said stationary mount of a vehicle chassis.

4. A magnetorheological fluid actuated damper as claimed in Claim 1, wherein: the second cylinder is the cylinder that has said control arm mounted at said end of said second cylinder, and that is mounted on bearings to allow rotation of said second cylinder relative to said chassis; and the first cylinder is the cylinder that is mounted to said stationary mount of a vehicle chassis.

5. A magnetorheological fluid actuated damper as claimed in any preceding claim, wherein said cylinder that is mounted to said stationary mount of a vehicle chassis is unable to rotate.

6. A magnetorheological fluid actuated damper as claimed in any preceding claim, wherein oscillation of said control arm causes said cylinders to rotate relative to one another.

7. A magnetorheological fluid actuated damper as claimed in any preceding claim, wherein said magnetic field is generated by a coil.

8. A magnetorheological fluid actuated damper as claimed in Claim 7, wherein said coil is in contact with at least one of said cylinders.

9. A magnetorheological fluid actuated damper as claimed in Claim 7 or Claim 8, wherein said coil is attached to an electronic circuit allowing variation in current supplied to said coil to adjust the viscosity of said magnetorheological fluid.

10. A magnetorheological fluid actuated damper as claimed in any of Claims 7 to 9, wherein said magnetic coil comprises solenoid windings positioned within said first cylinder.

11. A magnetorheological fluid actuated damper as claimed in any of Claims 6 to 9, wherein said magnetic coil comprises solenoid windings positioned within said second cylinder.

12. A magnetorheological fluid actuated damper as claimed in any of Claims 6 to 9, when appendant from Claim 2, wherein said magnetic coil comprises solenoid windings positioned within said third cylinder.

13. A magnetorheological fluid actuated damper as claimed in any of Claims 6 to 12, wherein said coil is connected to an electronic circuit such that said circuit can provide a varying charge to said coil to create a magnetic field in the vicinity of said coil.

14. A magnetorheological fluid actuated damper as claimed in Claim 13, wherein said electronic circuit is controlled by an amplifier controlled by a controller that receives feedback from sensors measuring the displacement and velocity of said wheel and the chassis of said vehicle.

15. A magnetorheological fluid actuated damper as claimed in any preceding claim, wherein a second end of said control arm is pivotally mounted to a point on the knuckle of a wheel of said vehicle such that the vertical motion of said wheel causes said control arm to move and rotate said cylinders relative to one another.

16. A magnetorheological fluid actuated damper as claimed in any preceding claim, wherein an increase in said magnetic field causes an increase in the viscosity of said magnetorheological fluid which in turn increases the amount of force necessary to rotate said cylinders relative to one another.

17. A magnetorheological fluid actuated damper as claimed in Claim 16, wherein said increase in viscosity decreases the amount of movement of said control arm when said cylinders rotate relative to one another.

18. A magnetorheological fluid actuated damper as claimed in any preceding claim, wherein said damper is mounted on the upper control arm of a double-wishbone suspension system.

19. A magnetorheological fluid actuated damper as claimed in any of Claims 1 to 17, wherein said damper is mounted on the lower control arm of a double wishbone suspension system.

20. A magnetorheological fluid actuated damper as claimed in Claim 19, wherein said double wishbone suspension system is a low floor installation.

21. A magnetorheological fluid actuated damper as claimed in any of Claims 1 to 17, wherein said damper is mounted on the trailing arm of a solid axle suspension system.

22. A magnetorheological fluid actuated damper as claimed in any of Claims 1 to 17, wherein said damper is mounted to the lower control arm of a strut suspension system.

23. A magnetorheological fluid actuated damper as claimed in any preceding claim, in which the said cylinder mounted on bearings to allow rotation of said cylinder relative to the other cylinders is comprised of non-ferrous material.

24. A method for adjustably dampening the suspension system of a vehicle through the use of a magnetorheological fluid actuated damper, said damper being as claimed in any preceding claim, the method comprising the steps of:

determining a desired level of dampening;

reading feedback from sensors on the vehicle; and

controlling the viscosity of said magnetorheological fluid through the application of a magnetic field on said magnetorheological fluid such that the resistance to rotation of said relatively rotatable cylinders changes in response to the change in viscosity of said magnetorheological fluid.

25. A method as claimed in Claim 24, wherein one of said cylinders is attached to the chassis of said vehicle such that said cylinder cannot rotate.

26. A method as claimed Claim 25, wherein said other cylinder is attached to a control arm of the suspension system of said vehicle such that said other cylinder can rotate relative to said stationary cylinder in reaction to vertical movement of a wheel of said vehicle.

27. A magnetorheological fluid actuated damper substantially as herein described, with reference to or as shown in the accompanying drawings.

28. A method for adjustably dampening the suspension system of a vehicle through the use of a magnetorheological fluid actuated damper substantially as herein described, with reference to or as shown in the accompanying drawings.

21

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Claims searched: 1-28

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): F2S (SBG, SXB)

Int Cl (Ed.7): F16F 9/53, 13/30

Other: Online WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP 1134100 A2	(AZIONI) See especially Figs 1, 2 and 3.	1 at least
X	US 6318522 B1	(JOHNSTON et al.) See abstract; Figs. 1 and 2; and Column 3 line 50 to Column 4 line 61.	1 at least
X	DE 19839888 A	(MUHR & BENDER et al.) See abstract and Figs 3 and 4.	1 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		